

ITk Pixel Powering

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The University of Oklahoma
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SLAC
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Powering

A serial powering scheme for the ATLAS pixel detector at SLHC

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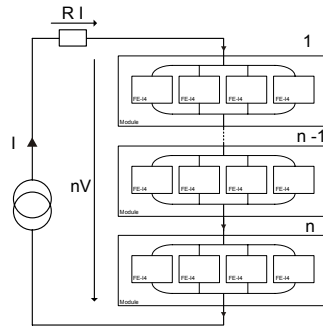


Figure 1. Schematic design of a SP scheme. The current is reduced by a factor n , where n is the number of modules in the chain, with respect to a parallel powering scheme where the same number of modules is powered by a constant voltage.

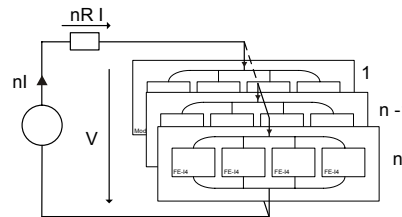


Figure 2. Schematic design of a parallel powering scheme.

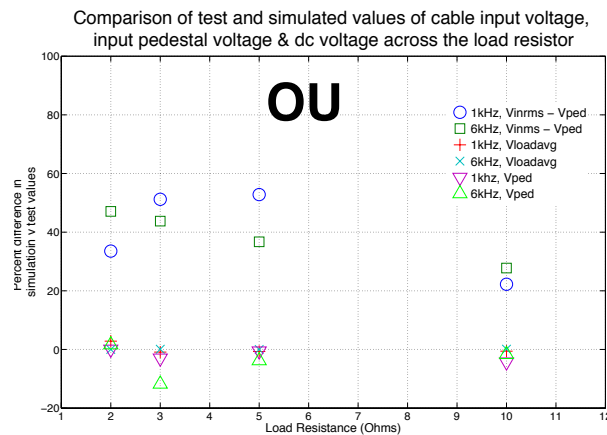
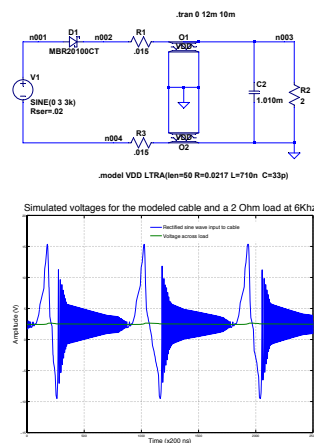
- Two ITk Pixel powering schemes are under development
 - Serial powering - baseline
 - Pulsed powering (parallel)
- Neither have been demonstrated to work in complete services chain
- Both require power supply design

Both

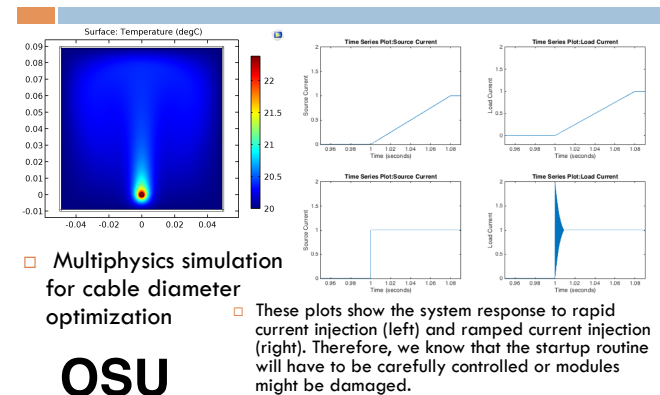
- Need more manpower
 - Serial power effort has been mostly from Bonn University until recently (3 more European institutes & OK State)
 - OU is only participant in Pulsed Powering R&D - Supported by ATLAS Project Office in first 2 years.
- Need power supply designs and full scale tests (100 m cable plant) in time to write TDR
- Will an ITk pixel workshop be called in fall 2015 to bring other institutes up to speed, get them involved?

OU & OK State

- Build knowledge base and libraries for power system simulations
- Build & operate full scale, generic power test stand to verify simulations
 - Readout system compatibility (3 at this time for ITk pixel R&D)



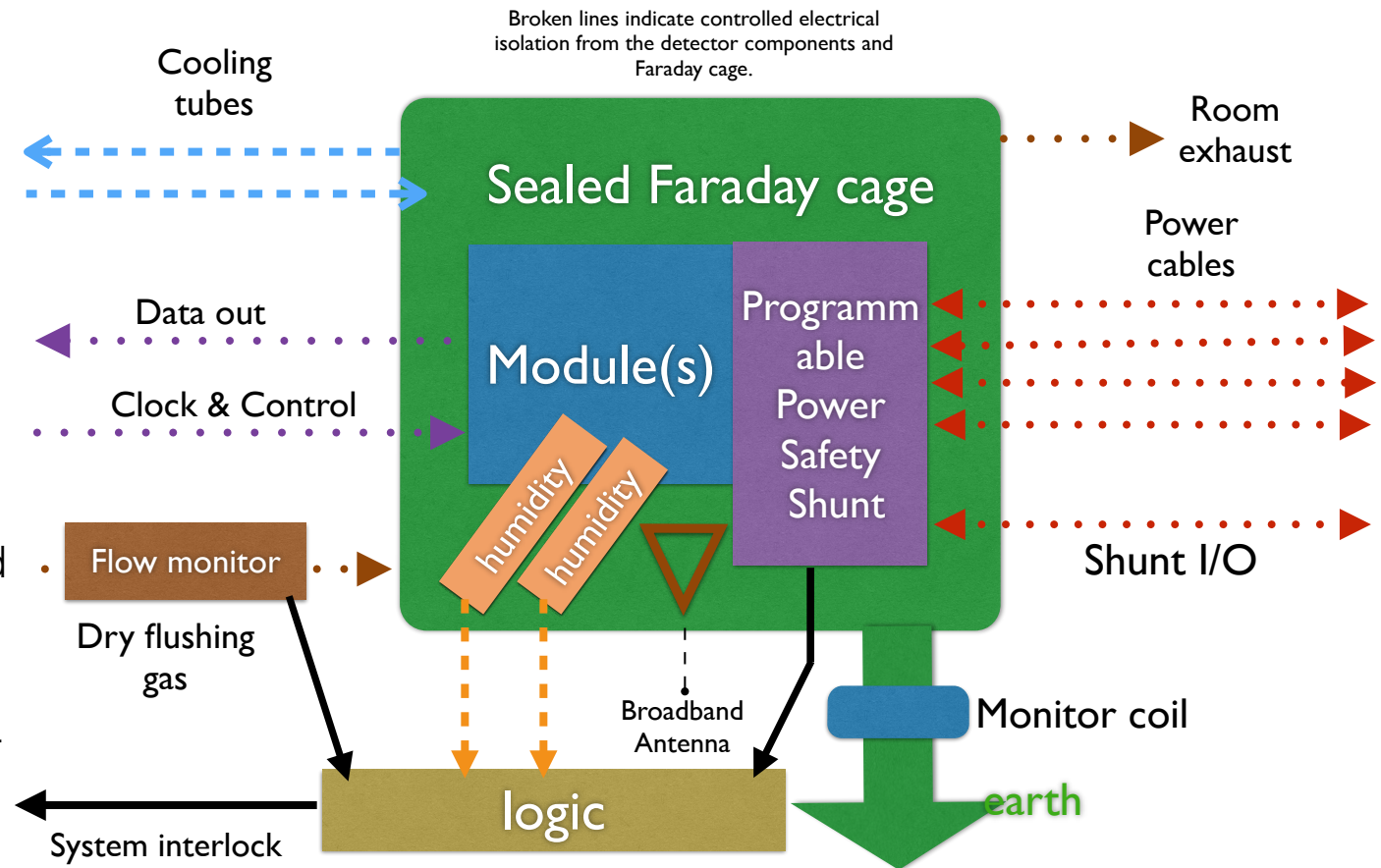
Serial Powering: Results of the simulation



OSU

Test System Physical Layout - to be built at OU

- Remote control readout, operation
- Realistic, full length cables and connectors (Pixel to start)
- EMI/RFI susceptibility and radiation measurement
- Cooling, detector safety, etc...



OU Powering Production

- Many unknowns
 - What power supplies get built?
 - Where do they get built?
 - Who pays?
 - Are patch panels required?
 - Do cables, connectors, power supplies need engineering supervision during production?
- Too early to define a production role for power components...

Serial Powering: OSU Production plans

- These plans are contingent upon the successful design of a serial powering system
- We can be responsible for the production of services
- We can also be responsible for the production of power supplies
- If serial powering is the US ATLAS Deliverable then serial powering will be our major project
- We plan to have 2 graduate students and 2 EE undergraduate students working under Welch's supervision.

US Funding for ITk Pixel Power

- Ends 2015
 - OK State U.: S. Welch support ends September, 2015
 - To date: simulations, interconnect research
 - OU: R. Boyd support ends April 2016 (base grant renewal?)
 - TWEPP 2013 poster, JINST proceedings, IBL authorship project (A.A. Hasib)
 - No support for students exists but OU has recruited 4 undergraduates with very limited time, may be able to resume testing this fall
 - Only tiny amount of material support from 3 year base grant

R&D Summary

- The two proposed solutions, serial power and pulsed power, have been largely supported by two institutes: OU and Bonn University
 - Oklahoma State and 3 European institutions have joined the serial power R&D effort in the past year
 - OU continues to be the only institute investigating pulsed powering
 - There is no demonstrated solution for ITk pixel power
 - There are no power supplies suitable for either solution
- Support for both powering efforts in the US could end soon if key personnel are lost

Power Production Summary

- In general, the stuff of power supply systems have been “core” items for Pixel Detector scale projects
- However, construction demands may result in parts of the power system being built in the US, a la several IBL cables
- Even if construction takes place elsewhere, the IBL experience, similar in technology if not scale, suggests that close supervision of and interaction with vendors is essential to success
- Bottom line: the only US deliverables for power supply systems may be specifications and engineering supervision of production

further information

Material Requirements

- More important than ever that we develop capability to do low frequency cable measurements to characterize their response in the power system simulations
 - Equipment (VNA) doesn't seem to exist in US ATLAS institutes
 - Expensive, even if we hire measurement out to industry (and test stand needs would not be met)
- Readout hardware (\$\$\$) needed for multiple efforts at OU and OK State but critical to power development
- Real modules are also not free. Can't do meaningful power system test without them
- Other expenses: PPSP chip support (for serial powering DCS), EMI/RFI measurements jigs, etc.

Serial Powering

FE power consumption (SP friendly)



Current generation FE chips have

Laura Gonella, Fabian Hügging
CMS Pixel phase 2 power distribution review
25/03/2015

- **Current consumption dependent on rate**

- Experience w/ FE-I3 and FE-I4 shows that changing digital currents are bad!
→ For the next generation pixel FE chips make the digital current constant, independent of digital activity, i.e. maximum activity present all the time, higher average power, but same peak power

- Not clear how shunt power is dissipated on stave

- 4 European groups working on bench tests
 - Includes DCS chip, PPSP
 - Based on 4-chip FE-I4 modules (\$\$)

Pulsed Powering

- Achieves point-of-load regulation over the same wire pair that delivers power
- Compatible with serial powering and mitigates losses of shunt regulation by providing constant voltage across N modules, fails safe!
- When combined with resonant inductive coupling
 - Provides current reduction in cables by efficient air core transformer
 - Possibility for wireless power transmission into detector
- Must be engineered to not emit RFI/EMI into neighboring subdetectors

Comparison

	Serial powering	Pulsed Powering
Current reduction	yes	with resonant inductive coupling
Fails Safe	no	yes
Added power dissipation in detector	prop. to (module max. current - instantaneous current)	prop. to (LDO + rectifier resistance (few milliohms))
Max cable current	Maximum of one module	depends on transformer design
Module power isolation	not possible, N voltage references	yes
FE design dependency	shunt regulator	LDO voltage regulator